POWER

Vol. 39. NEW YORK, JUNE 23, 1914 No. 25

"AND SO THE POOR DOG GOT NONE"

First Buckeye-Mobile in Commercial Service in America

SYNOPSIS—The first Buckeye-mobile sold and installed in America is of 115 hp. capacity. It occupies in actual floor area a space 17 ft. 10 in. long and 7 ft. 6 in. wide. The coal consumption per indicated horsepower on test was 1.33 lb. It is directly coupled to a 75-kw. alternator.

The first Buckeye-mobile sold and installed in America (there is an experimental one used at the works of the makers, the Buckeye Engine Co., Salem, Ohio) is in operation at the works of the International Cork Co., Sutton St., Greenpoint, L. I., N. Y.

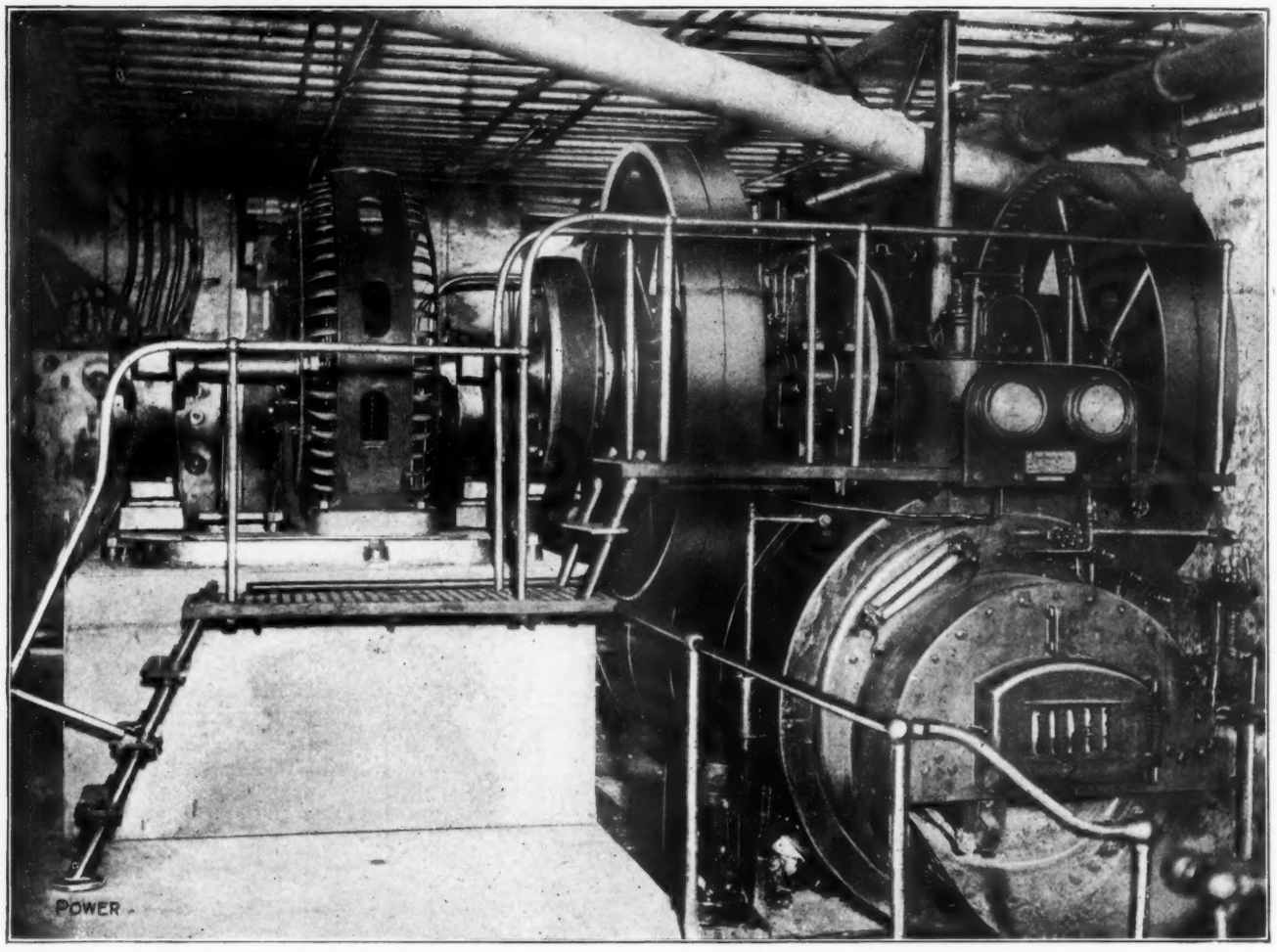

FIG. 1. FRONT VIEW OF THE 115-HP. BUCKEYE-MOBILE AT THE INTERNATIONAL CORK CO., GREENPOINT, LONG ISLAND, N. Y.

This particular unit, Fig. 1, is of 115 hp. capacity and stands 9 ft. high from the base to the top of the engine flywheel. As the basement where it is placed is low, it was necessary to put the outfit in a pit 2 ft. deep, giving an 18-in. clearance between the top of this flywheel and the ceiling rafters.

The unit sets on a concrete foundation and is anchored by only two 1¼-in. bolts at the left front foot; the opposite foot rests on two 1½-in. rollers, supported by a channel plate. The two center feet each rest on four rolls of the same size and both rear feet are on two 1½-in. rolls. This arrangement gives free expansive movement. The furnace contains 38 sq.ft. and the 91 tubes 262 sq.ft. of heating surface, a total of 300.

Fig. 2 is a rear view of the unit. The generator is on a concrete foundation and the base is level with the operating platform of the engine. A 7-kw., 125-volt exciter unit is belt driven from the engine shaft at 1210 r.p.m.

The engine shaft is coupled to a 75-kw. Westinghouse, alternating-current generator, which produces 220-volt, three-phase, 60-cycle current at 257 r.p.m. The coupling is flexible, to allow for change in alignment, due to any slight movement of the Buckeye-mobile.

The principal weights of the unit parts are as follows: The boiler, with feet and saddle, weighs 12,000 lb., or six tons; the bedplate, 2400 lb.; the engine cylinder, 1400 lb.; the crankshaft, 1500 lb.; and the two flywheels, 3000 lb.

In Fig. 3 are shown the dimensions of the 115-hp. Buckeye-mobile, the total length of which is 17 ft. 10 in.; a space of about 10 ft. 6 in. is required for removing tubes, at the head end, and 4 ft. for removing the super-

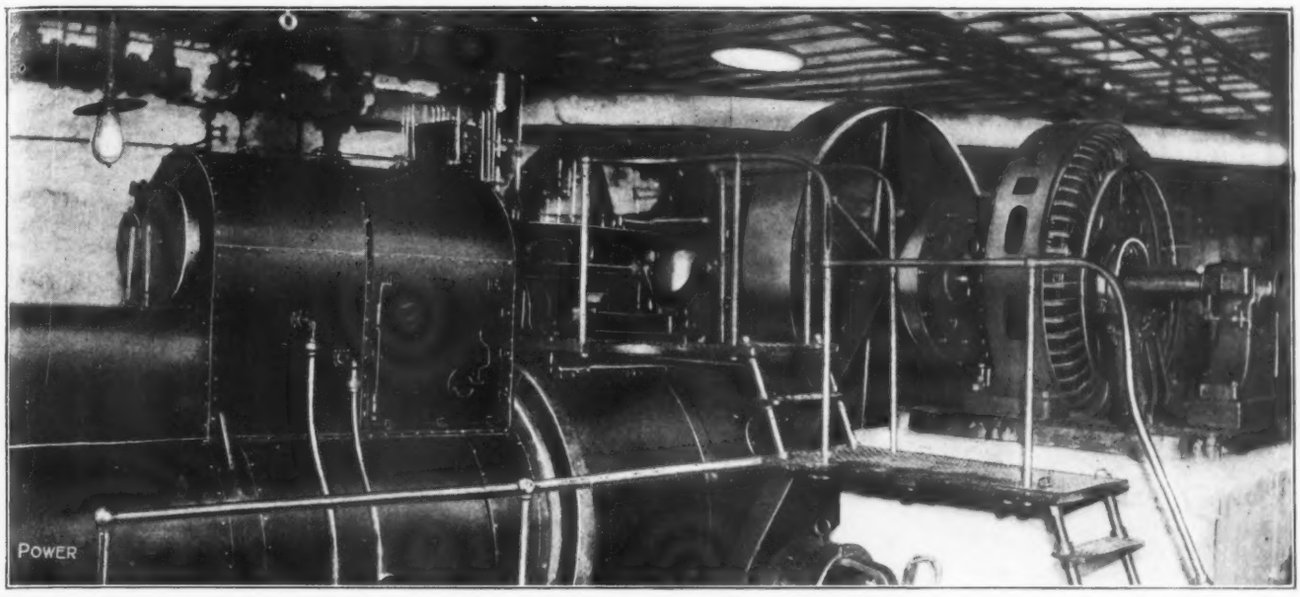

FIG. 2. VIEW OF THE BUCKEYE-MOBILE FROM THE SIDE

heater from the rear end, making a total required length of 32 ft. 6 in. The 10-ft. space in front of the boiler, however, is necessary for a firing place in any event. The width of the engine is 7 ft. 6 in. and the generator adds, with its foundation, 6 ft., or a total of 13 ft. 6 in. The total ground area required by the unit is 13 ft. 6 in. by 32 ft. 4 in. for 115 hp. in output.

The following figures were obtained at the shop test of the unit on Apr. 1:

NO. 4 BUCKEYE-MOBILE, 115 HP., NONCONDENSING	
Pocahontas coal	14,500 B.t.u.
Duration of test, 11 a.m. to 7 p.m.	8 hours
Speed	248 r.p.m.
Indicated horsepower	118
Total steam per hour	1,574.5 lb.
Steam per i.hp.	13.3 lb.
Total coal per hour	156.4 lb.
Coal per i.hp.	1.33 lb.
Boiler pressure	210 lb.
Superheat, high-pressure cylinder	171 deg.
Superheat, low-pressure cylinder	56 deg.
Temperature feed water	192 deg.
Temperature stack gases	398 deg.

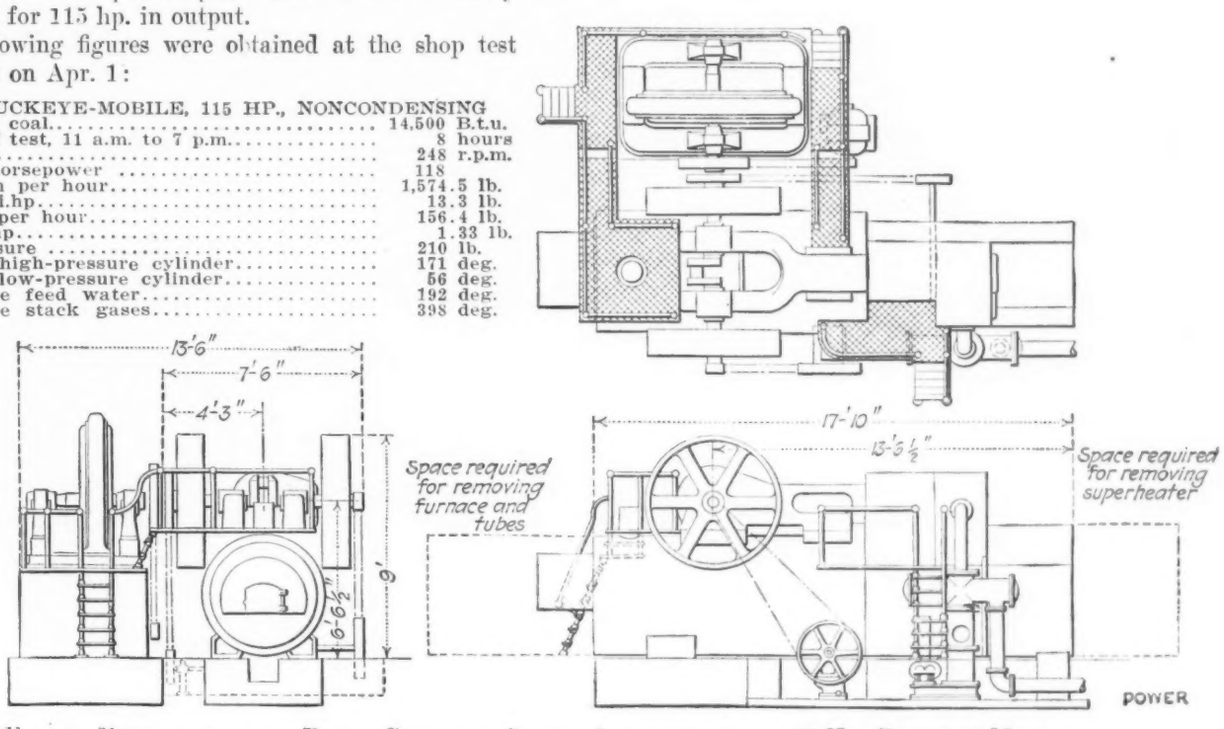

FIG. 3. ELEVATIONS AND PLAN, SHOWING SPACE OCCUPIED BY A 115-HP. BUCKEYE-MOBILE

The diagrams, Fig. 4, are from the high- and low-pressure cylinders taken during the shop test.

This first installation is a good example of the adaptability of the Buckeye-mobile in restricted places where it would be impracticable to install the ordinary type of boiler and engine.

Due to the demand for more power (an additional building is being erected) it was necessary for the company to solve the problem of additional power units. The original power plant is in the basement of the brick building. The boilers occupy the width of the boiler room and the engine is on the opposite side of the basement, and separated from the boilers by a brick wall. The basement is about 10 ft. high, and any additions in the ordinary steam boiler and engine equipment would require considerable alterations to the building.

It was finally decided to install a Buckeye-mobile of 115 hp. capacity. This would eliminate changing the boiler room, save floor space, provide a "two-in-one unit," and, furthermore, produce a horsepower-hour more economically than any other type of steam prime mover.

The time required to place the unit after delivery was eight days, two days longer than with favorable conditions for handling the parts.

From the figures given in the test it will be seen that the unit will deliver a horsepower-hour on less than 1½ lb. of coal, running noncondensing. In fact, the builders guarantee to forfeit $1000 for every $\frac{1}{10}$ lb. of coal required per indicated horsepower above the guarantee, with a nominal bonus for saving in fuel below the guaranteed amount, the calorific value of the coal being the basis of the guarantee.

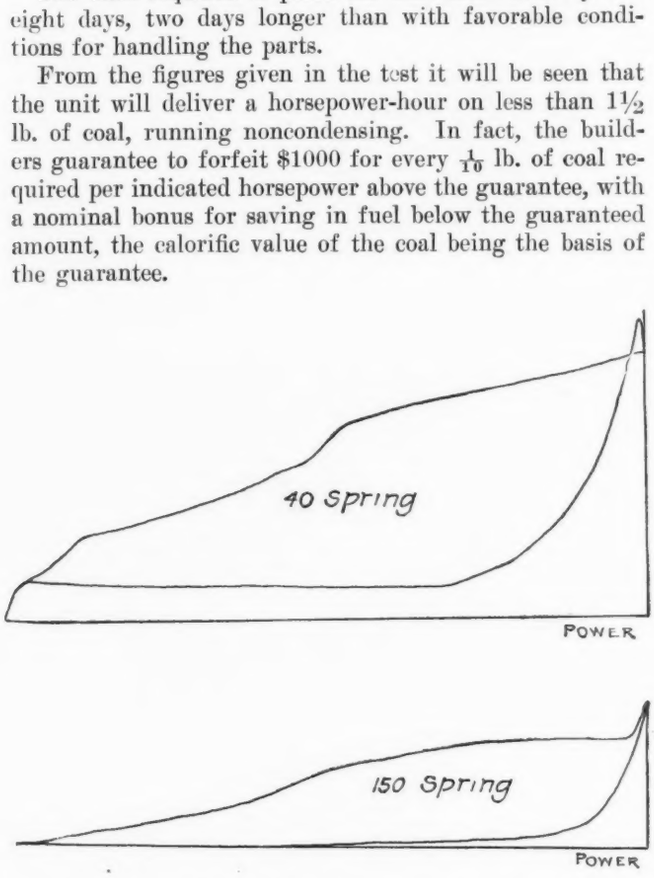

FIG. 4. DIAGRAMS TAKEN DURING SHOP TEST

Aside from the compactness of the power plant the big thing is that this small size of Buckeye-mobile produces power on less fuel than the largest central-station unit, and the consumer of power in small quantities can produce it as cheaply as if the ordinary boiler and engine unit, many times this capacity, were used.

Use of Rheostats to Control Alternator Voltage

There are usually two rheostats on each alternator panel, one in the exciter field circuit and the other in the alternator field circuit; by the use of which the alternator voltage may be adjusted. The question often arises as to which of these should be used.

Exciters are nearly always rated at 125 volts, but this does not mean that they are to be run at this voltage; usually it is less than this. The alternator fields consume the full output of the exciter, whereas only about 2 per cent. of the exciter capacity is used in exciting its own fields. Therefore, a resistance inserted in series with the alternator field will consume many times the power lost when a proportionate resistance is inserted in series with the exciter field. Hence it is more economical to operate with the alternator rheostat cut out and with proper exciter voltage to maintain the required alternator voltage. The only exception to this rule is in case the resultant exciter voltage is so low that the exciter is operating far below the knee of its magnetic saturation curve so that an unstable voltage results.

When two alternators are to be operated together their exciters are first paralleled, the incoming exciter voltage being first made the same as that of the unit in operation. In order to adjust the voltage of the incoming alternator to correspond with the alternating busbar voltage, it is then necessary to use the rheostat of the incoming alternator. When the machines are synchronized, the alternator rheostats are adjusted to reduce the cross-currents to a minimum. However, the general rule still holds that as little resistance as possible should be inserted in the alternator field circuits.

When a Tirrill regulator is used the exciter rheostats are set at predetermined points corresponding to very weak fields. The alternator rheostats are usually cut out altogether, or nearly so. The regulator then short-circuits the exciter field rheostats controlling the exciter voltage so as to maintain steady alternating busbar voltage.

Tightening Commutators in Use

Quite frequently, the commutator segments of large direct-current machines develop high or low bars and show signs of loosening; also, new segments are inserted and it becomes desirable to tighten up the commutator. This requires baking the commutator to be most effective. The shellac binder should be softened and the commutator tightened while hot, then as it cools, the shellac which has run into all the interstices, sets and binds the whole into a solid unit.

It would be a rather difficult task to remove a large commutator to bake it, and it is, of course, impossible to bake armature and all. An equivalent effect can be obtained quite simply. The machine may be operated as a generator with the armature short-circuited and a weak field to obtain full-load current or with a low-resistance artificial load. The brushes should be materially shifted from the neutral point. As a result of this shifting they are brought into a zone where there is considerable difference in voltage between adjacent bars. The brushes covering these bars cause rather heavy local currents to flow through the commutator segments and brushes, heating them without unduly heating the armature itself.

There will be some sparking, but this is usually immaterial as the commutator will later be turned down. When the commutator is thoroughly heated, care being taken not to overheat and melt the solder in the risers, the tightening screws are brought up and the commutator allowed to cool. When cool it may be turned down and smoothed, the brushes returned to their correct operating position, and any accumulated copper removed from under them. The machine is then ready for operation again.

The New 25,000-kw. Parsons Turbine, at the Commonwealth Station in Chicago, is said to have done a kilowatt hour on 18,300 B.t.u., and made a sustained run on 1.92 lb. of coal containing 10,300 B.t.u. per pound, with a 58 per cent. load factor.

An Electric Diesel-engine Railroad Motor Car was tested in southern Sweden last January. It weighs 33 tons and was run at a speed of 34 miles per hour on level track, and at about 20 miles an hour on a grade of 1 in 100. Altogether 2200 miles were covered. The consumption of crude oil averaged 9.3 lb. per mile, according to the Zeitung des Vereines Deutscher Eisenbahn Verwaltungen.

Pontchartrain Hotel Plant Records

By E. Y. Dow

The Pontchartrain, one of Detroit's well known hotels, is a 15-story structure containing 450 rooms. As usual, the building requires varied services, including lighting, general power, elevators, refrigeration, vacuum cleaning, hot water for house and laundry, heating, etc. The plant contains eight electric and two hydraulic elevators, 11 fans, 12 centrifugal motor-driven pumps and various machines with motors ranging from ½ to 40 hp. There is also an air washer with its fans and pumps and a small machine-repair shop, which requires more or less power.

Steam is furnished at 100 lb. for the direct-acting pumps and at 2 lb. pressure for the heating by the Murphy Power Co., and also current for lighting and power. Considerable ice is used in the hotel and some refrigeration is required. Two 25-ton, motor-driven Wisconsin carbonic compressors having a capacity to make 24 tons of ice in 24 hr. were installed to handle this load, and as satisfactory rates were not offered by the

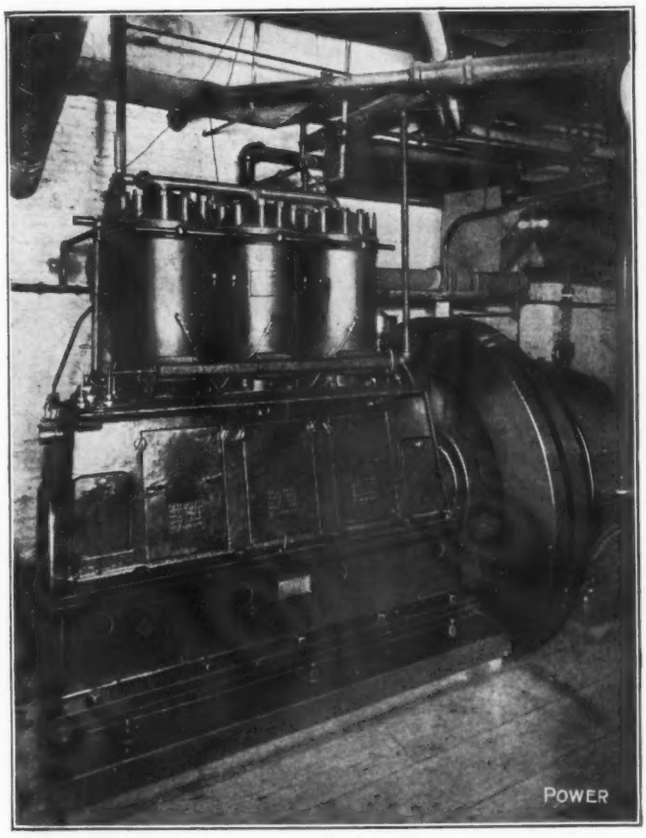

FIG. 1. THE 185-HP. GAS-ENGINE UNIT

central station, a gas-engine-driven generating unit was purchased primarily to care for the refrigerating load and reduce the maximum demand on the central station. The engine was a three-cylinder Nash, rated at 185 hp. and directly connected to a Western Electric three-wire, 125-250-volt generator.

In addition to the refrigerating load, which for the last two months has been 20 tons above the average, due to carrying the refrigeration in three outside buildings, the generating unit has operated the elevators, fans and electric-driven pumps, leaving the lighting for the central station. In the early morning hours it has frequently carried the entire load. By utilizing the jacket water and passing the exhaust gases through a heater, the unit has also supplied sufficient hot water for the kitchen and laundry. The engine uses city gas at a cost of 45c. per 1000 cu.ft. and a complete record of the plant for the month of February shows that with its varying power

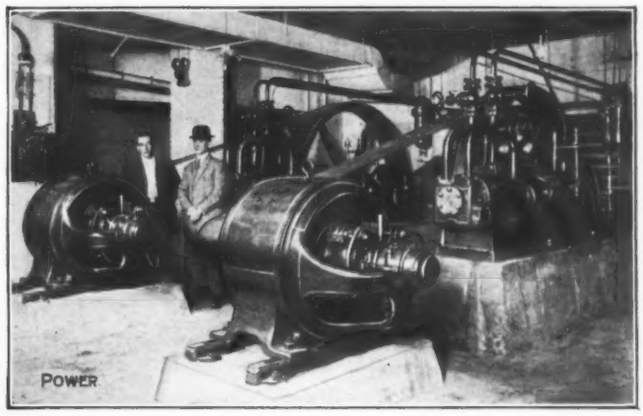

FIG. 2. THE REFRIGERATING PLANT

load it is supplying cheaper current than the central station. Following is a tabulation of the results:

Total gas consumption, cu.ft.	1,565,700
Total current generated, kilowatt-hours	52,100
Cost of gas at 45c. per 1000 cu.ft.	$704.57
Oil and waste	24.91
Interest and depreciation, 15% on engine, generator and switchboard	85.00
Labor	28.00
Total cost	$842.48
Former cost of hot water	250.00
Net cost of current	$592.48
Cost per kilowatt-hour, cents	1.137
Current purchased, kilowatt-hours	42,235
Total cost	$744.19
Cost per kilowatt-hour, cents	1.762

It is apparent that there is a difference in the cost of current of over 0.6c. per kw.-hr. and even without the reduction caused by the hot water, the difference is 0.15c. in favor of the gas engine. With the expensive fuel used this is an "eye-opener." It may well be imagined that a steam plant would do much better, as it would furnish the live steam for the pumps and the exhaust steam would be available for heating.

Utah Breaks Coal Record—The production of coal in Utah in 1913 was 3,254,828 short tons, with a value at the mines of $5,384,127, according to E. W. Parker, of the United States Geological Survey. In 1912, for the first time, Utah's coal production exceded 3,000,000 tons, the output in that year amounting to 3,016,149 short tons, valued at $5,046,451, a gain of more than half a million tons over 1911; nearly a quarter of a million tons more was mined in 1913. In 1912 the industry suffered from a scarcity of labor due to the exodus of foreign miners to the scene of war in the Balkan States, but the returns for 1913 indicate a plentiful supply of labor, as an increase of more than 800 men were employed in the coal mines compared with the preceding year.

Nearly 90 per cent. of the total coal production of Utah is mined in Carbon County, which contains a large part of the great Uinta Basin. This county produced in 1913, 2,880,102 short tons, out of a total for the state of 3,254,828 tons.

Comparing Boiler Laws

By Danny Hogan

The article in Power of May 19, by J. W. F. Macdonald, on Canadian boiler rules, is worthy of further discussion, in view of the steps now being taken to formulate a model boiler law in the United States It is, or should be, the aim of such law makers to establish standards easily understood by builder, buyer and inspector, to avoid ambiguity and to fix values as regards tensile and shearing strengths, and factors of safety, so that he who runs may read aright. Even though it was not realized in the making, doubtless this view was in mind in forming the Canadian laws, but they fall far short of the Massachusetts rules in several respects.

For example, Massachusetts sets certain factors of safety to be used on boilers installed before the law was passed, fixes tensile-strength values on such boilers where stamps cannot be found, gives estimates on rivet diameters per thickness of plate, and varies the factor of safety on lap-seam boilers, on account of age. These important details are not contained in the laws of our neighbors, and, by so much, owners and inspectors are at a loss to know what to do; they are no better off than before.

As to new boilers, on the tensile-strength question they sit in our pew, but do not prohibit the use of flange steel. It follows that, with a high tensile strength, a boiler will be allowed more pressure, while experience shows that the best steel for shells (or elsewhere) contains less carbon and sulphur content, and is therefore more ductile or less brittle.

Why is it that high tensile strength is considered desirable for any boiler purpose, and especially for shells, in which the plate is cold stretched to points beyond the elastic limits? Certainly for such treatment the mildest, the most ductile steel is desirable, and Massachusetts requires this, while Canada grants more pressure on steel of higher tensile strength and resultantly less positive value.

A low-tensile-strength plate, although it is better, is penalized by less allowance as against the high-tensile-strength plate. There is great need of disposing of this question of tensile strength in order that all builders may be on an equality. The plate makers aim to produce the best plate possible, but in the art the range of tensile strength varies from 6000 to 8000 lb., and this cannot be avoided. If, therefore, a mean tensile strength, say, 56,000, is assumed and stamped, in the event of later tests showing less tensile strength, the plate maker is in trouble. Hence, if he must stamp 56,000, it follows that he will see that the carbon content is high enough to insure the tensile strength, which means more brittle steel. Therefore, in order to give the plate maker liberty to make the "best-ever" steel, we should take a low fixed tensile strength, not more than 52,000 lb., for plates 1 in. or less, and for plates above 1 in., for obvious reasons, 50,000.

Reverting to the Canadian rules, to rivet shear values, it appears that, assuming for lap seams the rivet shear to be 0.7 that of the plate tensile strength, it is not as correct a practice as that in the United States, because the Canadian rules have a wide range in tensile strength —from 52,000 to 65,000 lb. This gives a shear value range of from 36,400 to 45,500 lb for steel rivets. Thus the same lot of rivets would be given varying values due to the plate tensile strength. As a matter of fact, the United States standard, 42,000 lb., is a result of numerous tests by competent authorities and is accepted here as about the average value when made from extra-soft steel to comply with the Massachusetts requirements.

Our Canadian friends, apparently, have not profited by the numerous explosions in this country, due to failure of lap seams, for they have not prohibited lap-seam contraction; they merely require them to be triple riveted, and add 0.5 to the factor of safety on such boilers. The tendency in the United States is to rapidly abolish the lap-seam boilers, and not to permit new ones to be built. In this respect, comparisons are odious, or odorous, as you like.

Concerning the base factor of safety, 4.5 (where we use 5), and additions as penalties, I am of the opinion that the Massachusetts methods are better. The builder secures a contract guaranteeing a certain pressure. In Massachusetts, he knows exactly what to do to have the boiler accepted as standard. But in Canada, by using slightly heavier plate of high tensile strength and allowing for a few additions to the factor of safety, he can get the boiler passed for the required pressure, while as a matter of fact it would not be accepted in Massachusetts, Ohio and other localities in this country. Beyond doubt, in this respect the Massachusetts standards are the best.

On convex and concave heads, however, the Canadian rules are far and away ahead of those in force in this country, including the United States Government rules. I do not know what tests were made or who founded their convex-head rules, but on this detail I acknowledge that they have the advantage and congratulate them. The details on workmanship (Ontario rules, pages 63 to 67) are, with one exception, excellent, and, no doubt, written by one thoroughly familiar with the best shop practice. The exception is in the matter of punching rivet and stay-bolt holes below size. The rules permit punching for rivet holes over $\frac{13}{16}$ in. diameter, $\frac{3}{16}$ in. less than full size, but they contain no limitation as to the thickness of the plate that may be so punched other than diameters greater than plate thickness. Here, we punch $\frac{1}{4}$ in. below size for plates $\frac{3}{8}$ in. and above, which results in the removal of about all the injured section of the plate. Furthermore, the heavier the plate, the greater the injury by punching; hence a limitation should be placed as to the thickness of plate that may be punched, and about $\frac{5}{8}$ in. should be the dividing line. American practice is about at this point.

The limitation of sheets and shells to 10 ft. in length, when made in full ring courses, is questionable for drums on water-tube boilers, but it is good practice for disposing of that atrocity, the single sheet on the bottom horizontal tubular boiler. In the United States no one has questioned the butt joint double strapped, with one row of rivets in double shear, having the outer row in single shear and double pitch. The joint has been in use for years here, and is accepted by all at its face value, usually 82 per cent. But in Canada, this form of joint is penal-

ized by raising the base factor of 4.5 to 5.5, whereas a lap-seam triple riveted would have 4.5 + 0.6, or 5.1.

I am of the opinion that this joint is worthy of more consideration, and, par efficiency, the equal of a butt triple-riveted seam. In regard to stay-bolts used in vertical and locomotive boilers, the general practice in the United States is to omit the washers, nuts, etc, but to finish them with a pneumatic tool, thus forming a neat and strong head on each end. Such work is now being done in a first-class manner, especially on large vertical boilers and in water legs of water-tube boilers. In doing this our builders' practice is to calculate the entire load to be supported by the bolt on the basis that pitch × pitch × pressure is the load, and no value is allowed for plate stiffness or load. Again, to be on the safe side, the load on stay-bolts is low, 6500 lb. for 1¼ in. and below, and 7000 lb. above 1¼. For weldless iron stay-bolts Ontario allows 7000 lb., and for steel ones less than 1½ in., 8000 lb. allowed and above 1½ in., 9000 lb.

With regard to the above, it may be said that the stay-bolts in portable boilers, either of vertical or locomotive types, the bending action is very small; it is practically negligible. But in these boilers internal corrosion is to be considered, and, in addition, it is practically impossible to examine such stay-bolted surface internally. Hence the importance of starting with a low stay-bolt value when building such boilers. In this respect, Massachusetts leads. Clearly such practice increases the factor of safety, and safety is, after all, what is sought.

It has been said also that in several respects it is difficult for an inspector to determine by the Canadian rules just how much of the law applies to boilers in use before the laws were passed. Distinctions were not clearly drawn as applicable to old boilers, and rules should be specific on such matters. Inspectors should have clear, definite instructions, for they are often called on to show why the pressure is ordered reduced and they must be able to convince the owner that the law is behind them.

Commenting on boiler laws in general, it is important that someone has the power delegated to him or to them to amend the rules when needed. For example, in Chicago, in 1903, the city inspector ruled a factor of safety of five should go in force, and, further, that no more lap-seam boilers should be installed. Later, he ruled that a second-hand boiler 15 years old or more, if reinstalled after reinspection, would not be allowed more than 10 lb.

In Ohio, a recent ruling raises the factor of safety on old boilers from 4 to 4.5. Compare, then, the value of this feature with the rules of the United States Government service on steamboat boilers, wherein the factor of safety of the shell or cylinder is about 3.5, based on a rule formulated in 1872, and which it now appears impossible to amend, owing to the fact that it would require an act of Congress to change it.

It is to be hoped that the proposed boiler rules of the American Society of Mechanical Engineers will be so clear and so complete that our Canadian cousins, as well as the states now without boiler laws, will see fit to adopt them, and thus secure the uniformity so greatly desired by builders, inspectors and owners.

Steam-Electric Power Plant at Hauto, Penn.—III

By Warren O. Rogers

SYNOPSIS—The piping in the Hauto plant is on the sectional plan. There are four main steam headers from the eight boilers and four main boiler-feed lines. The high-pressure steam pipes are dripped to a Holly drip system; the low-pressure lines are drained to a sump and the water is used for wetting the ashes.

With the exception of the boiler-feed pumps, Fig. 17, all others in the Hauto plant are in the turbine-room basement. The three boiler-feed pumps are in the pump, pipe and heater bay, between the turbine room and the boiler house. Each is driven by a 125-hp., single-stage turbine at 2900 r.p.m. and can work against a head of about 270 lb. These pumps take water from the two open heaters through suction pipes connected to the main 14-in. header, piped to each heater.

Service Pumps

Feed water is supplied to the heaters by either of five compound duplex 8, 12 and 14 by 12-in. service pumps. The first battery of three pumps is in the turbine-room basement, between Nos. 1 and 2 turbines, as in Fig. 18. The discharge of these pumps is connected to a 10-in. cross header above the water end, with stop valves in both header and riser discharge pipes; thus any pump or section of the header can be cut out of service without interfering with the operation of the other pumps. The crossheader is connected with two main 12-in. lines which terminate in a 12-in. header, the connections being on each side of the feed-water heaters. Fig. 19 shows the details of this piping in the turbine-room basement.

Feed-Water Piping

The feed-water header is back of and above the boiler-feed pumps. Each of the two feed-water heaters has a capacity of 6000 lb. of water per minute with a maximum of 10,000 lb., and rest on concrete piers, as shown in Fig. 17. Each heater is connected to the 12-in. header by two 6-in. pipes, one on the outside of each connection of the feed pipes from the service pumps. This permits of four sources of feed water and practically eliminates any interruption of the supply.

The intake water to the service pumps comes to a main 24-in. header through two 24-in. pipe lines leading to the condenser intake tunnel. This header runs along the rear side of the basement, feeds both batteries of service pumps, and terminates above each battery, as in Fig. 18. Two 12-in. pipes extend from it to a 14-in. header about the pumps, from which 12-in. pipes connect to the suction side of each. The ends of the 14-in. header connect with two 14-in. pipe lines which end in the condenser discharge tunnel. This gives three sources of feed-water supply for each battery of pumps.

In addition to the boiler-feed pumps there are two com-

pound injectors for emergency use discharging into two 6-in. headers in the header room, Fig. 20. The boiler-feed pump 4-in. discharge pipes also connect with a 12-in. header, and both headers are tied by two 6-in. pipes. Two 12-in. mains branch out from each header and run to two 12-in. headers on the second floor of the boiler room, Fig. 21.

A venturi meter, placed in each vertical pipe, measures the total volume of water discharged by the feed pumps to the boilers. From the last-mentioned headers, four 8-in. feed lines extend up to and along the top of the boilers. The two outside pipes supply the first four boilers; the two inside pipes running to the four distant units, each feed line reducing in size to 4 in. at the far end. Details of the piping system are shown in the insert plan and in the elevation drawings, Fig. 22.

The 4-in. branch connections to the individual boilers are a decided departure from common practice. Each boiler is supplied with feed water from two main feed lines, the inlet connection being at each end of the two outside steam drums. From the two feed lines serving each set of four boilers a 4-in. branch line runs horizontally across the boiler and drops to a horizontal manifold on the boiler fronts. From this a riser extends to the top of the boiler setting and extends to a point above the center steam drum, ending in a double outlet tee, a branch pipe running to each outside steam drum and connecting at the top. As the other end of the two steam drums are similarly piped, the water tender can regulate the level from either boiler front by the valves in the vertical legs of the piping.

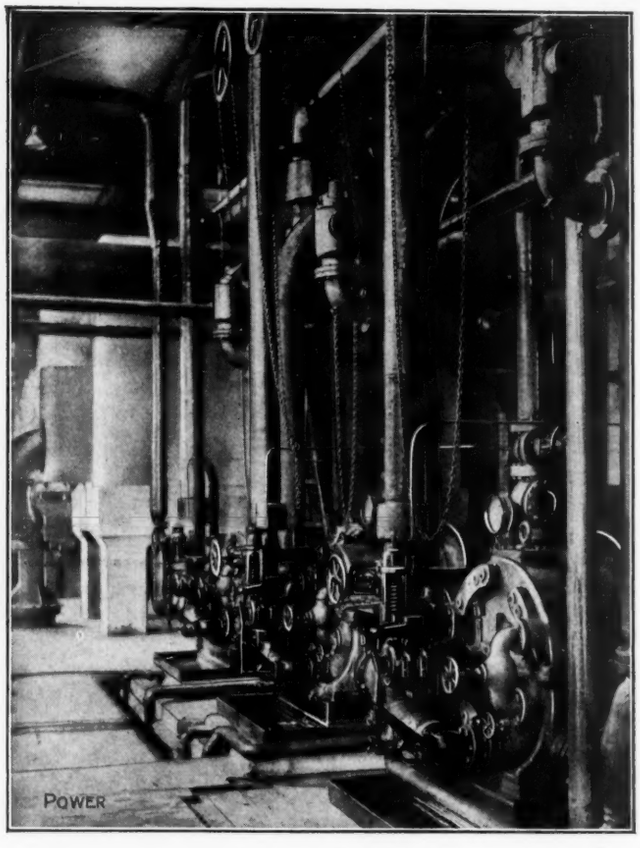

FIG. 17. TURBINE-DRIVEN CENTRIFUGAL BOILER-FEED PUMPS AND 6000-10,000-LB.-PER-MIN. CAPACITY HEATER

The vertical branch pipe connecting with the feed main and running down the fronts of the boiler setting contains a venturi meter for measuring the water going to the boiler to which it is attached. Both vertical pipes have a check valve, with a gate valve between them and the manifold, convenient for manipulation. These features are shown in Fig. 22. The second set of feed lines is connected to the other boilers in the same manner.

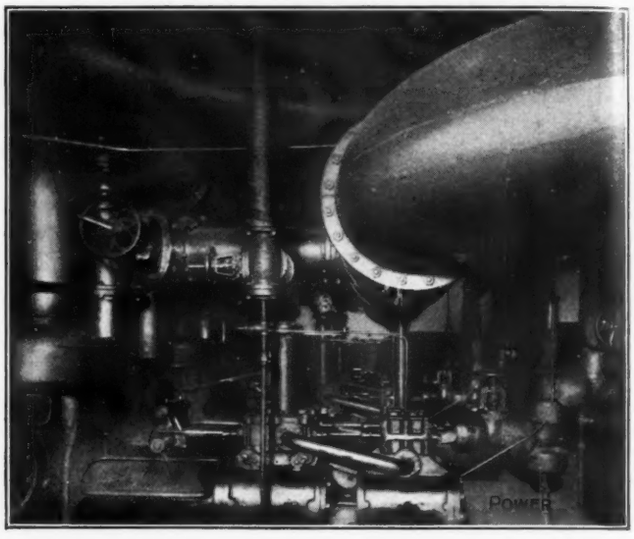

FIG. 18. SERVICE PUMPS IN THE TURBINE-ROOM BASEMENT

BOILER STEAM PIPING

A 6-in. connection from the center of each outside drum runs to the outside edge of the boiler setting, where each pipe connects to its respective inlet connection of the superheaters. The outlet of each superheater is on the opposite side of the boiler setting and is piped to a 6-in. branch to a 6x7x7-in. vertical manifold. From this manifold two 7-in. pipes connect to their respective 10-in. main steam headers running along the front of the boilers, just below the water-tender gallery, Fig. 23. This applies to the three boilers nearest to the turbine room. The other five boilers are similarly arranged, but the 7-in. pipes from the boiler manifolds join with the 10-in. main steam headers running along the top of the boilers after passing the fourth boiler nearest the turbine room.

These four 10-in. steam lines are brought around to the end of the boiler nearest the turbine room and then drop to the firing-floor level, where they are supported by a concrete pedestal. The four mains then pass through the floor and extend horizontally to the main pipe gallery, each pair of steam lines connecting with 15-in. compensating headers running lengthwise through the pipe gallery. The steam mains from the boilers and the compensating pipes are joined at intervals to 24-in. drums, in which there are long-radius expansion loops between the drums, Fig. 20. From the drums steam leads run to the turbines and pumps.

Each of the three main turbines is supplied by a 15-in. pipe attached to the respective 24-in. drum headers at the top, with a 15-in. stop valve between the drum and

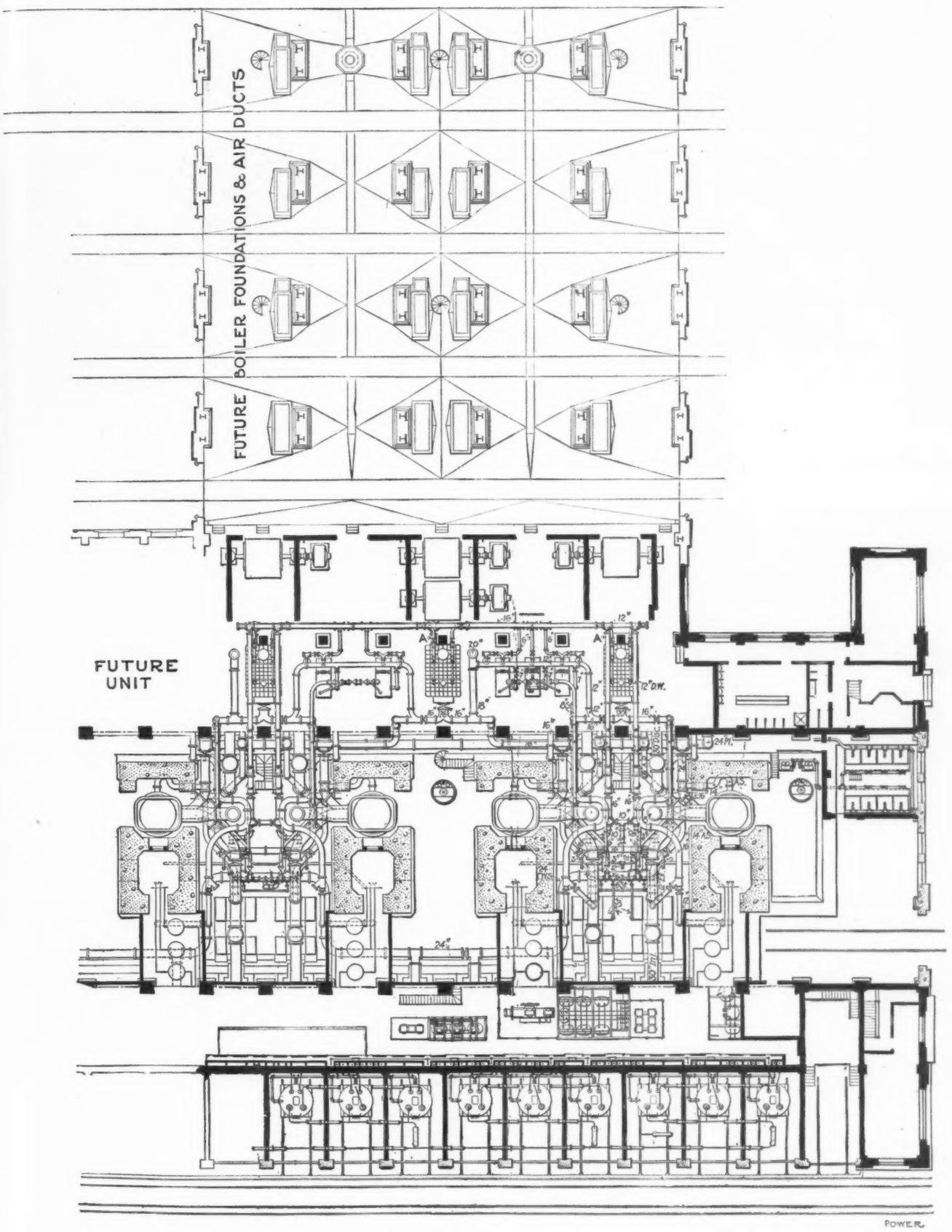

FIG. 19. DETAILS OF PIPING IN THE BASEMENT OF THE TURBINE ROOM. THE OUTLETS OF THE AIR DUCTS UNDER THE BOILERS ARE INDICATED AT THE TOP OF THE CUT

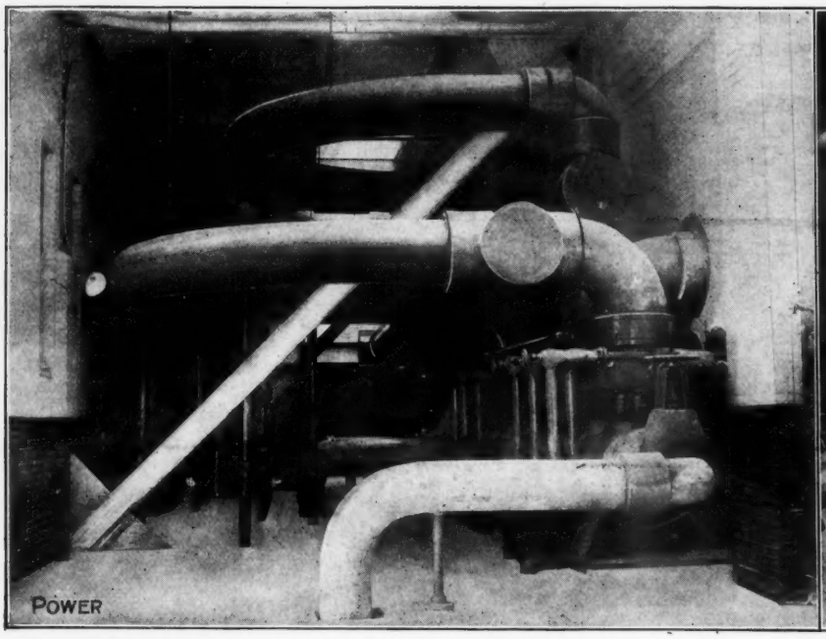

FIG. 20. HEADER ROOM, SHOWING EXPANSION LOOPS AND MAIN HEADERS

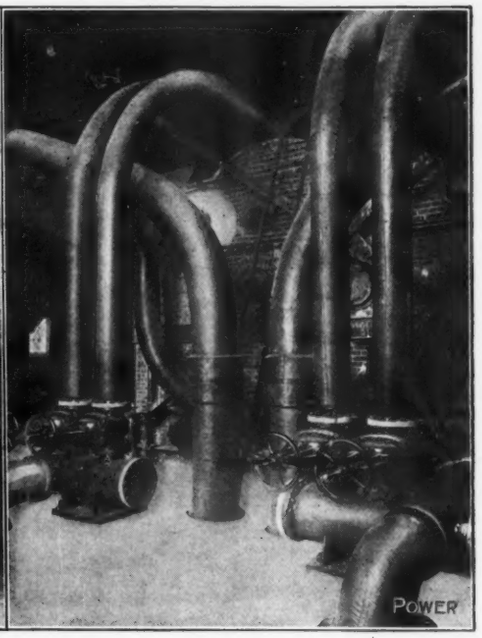

FIG. 21. FEED-WATER HEADERS AND MAINS, ALSO STEAM LINES FROM THE BOILERS

the pipe to the turbine. There are also 15-in. valves at the 20-in. drums for the compensating pipes, and all the valve stems conveniently pass through the wall between the pipe gallery and the turbine room and can be manipulated from the turbine-room gallery. This allows shutting off the steam from the compensating headers and from the turbine from outside the pipe gallery in case it is necessary.

CONDENSER EXHAUST-STEAM PIPING

The condensers of the main turbines are connected in pairs to 36-in. specially designed atmospheric relief valves, each having an air dashpot in conjunction with an independent, oil-operated cylinder working under 25 lb. oil pressure. As shown in Fig. 24, the cylinder is fitted with a dead-weight relief valve on its upper side. Each relief valve also has a float valve, which maintains a constant level in the water seal. To the 40-in. tee connection between each relief valve an expansion joint is attached, from the top of which a 44-in. square exhaust pipe extends up to an elbow and then runs horizontally under the header room; it then turns and connects to a round vertical 48-in. exhaust pipe which passes through the roof.

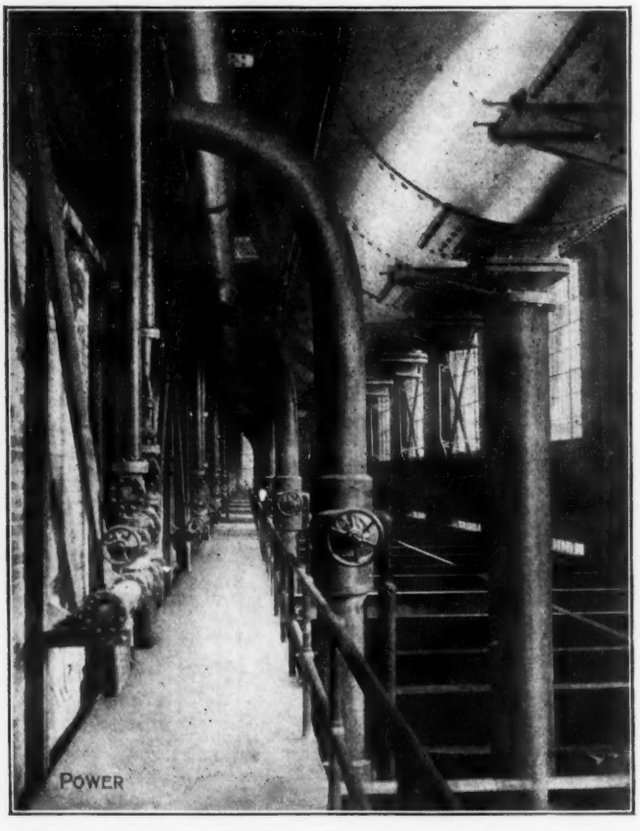

FIG. 23. WATER-TENDERS' AISLE, SHOWING COAL BUNKERS, HIGH-PRESSURE STEAM LINES AND FEED-WATER CONNECTIONS

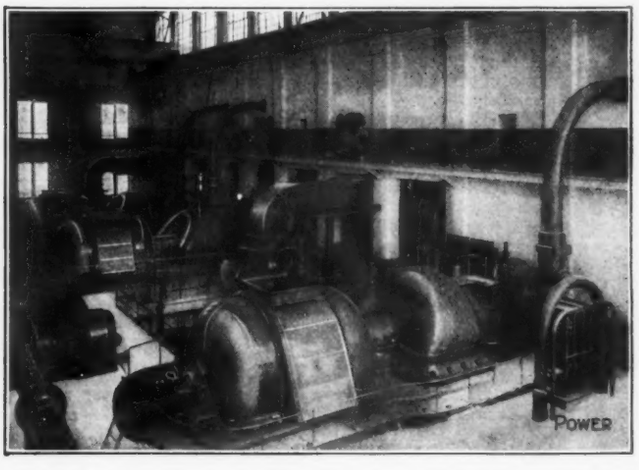

FIG. 24. SHOWING ATMOSPHERIC RELIEF VALVES AND ATMOSPHERIC EXHAUST PIPES FROM THE MAIN TURBINES